Project Reports
Year 9 Annual Report
July 1, 2007 through June 30, 2008

NAI Lead Team: Ames Research Center

Are you updating an existing project from Year 9?: no

Project Title: A workshop "Cyanobacteria in the Lunar Environment"

People

Provide information about people making a research contribution to this project during this Year 7 reporting period.

NOTE: Names listed here will be included in these lists: NAI Annual Report team, NAI e-mail, distribution, and NAI Online Directory

For the **"Role on Project"** column, identify as: PI, Co-I, Collaborator, Post-Doc, Research Staff, Undergraduate, Masters, or Doctoral Student. If other, please specify.

Name	Institutional Affiliation	Role on Project	E-Mail Address
Andrew Pohorille	NASA Ames Research Center	P.I.	Andrew.Pohorille@nasa.gov
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Objectives

In the following section indicate how the research objectives of this project align with the Objectives of the Astrobiology Roadmap. Specific Astrobiology Roadmap Objectives are organized under the seven broader Roadmap Goals.

Goal 1: Habitable Planets
Goal 2: Life in our Solar System
Goal 3: Origins of Life
Goal 4: Earth's Early Biosphere and its Environment
Goal 5: Evolution, Environment, and Limits of Life
Goal 6: Life's Future on Earth and Beyond
Goal 7: Signatures of Life

DETAILED TEXT DESCRIPTIONS OF THESE OBJECTIVES can be found on the NASA Ames Research Center Astrobiology website: http://astrobiology.arc.nasa.gov/roadmap/

Click on (check) the Roadmap Objectives associated with your project.

- ☐ 1.1 Models of formation and evolution of habitable planets
- ☐ 1.2 Indirect and direct astronomical observations of extrasolar habitable planets
- ☐ 2.1 Mars exploration
- ☐ 2.2 Outer Solar System exploration
- ☐ 3.1 Sources of prebiotic materials and catalysts
- ☐ 3.2 Origins and evolution of functional biomolecules
- ☐ 3.3 Origins of energy transduction
- ☐ 3.4 Origins of cellularity and protobiological systems
- ☐ 4.1 Earth's early biosphere
- ☐ 4.2 Foundations of complex life
- ☐ 4.3 Effects of extraterrestrial events upon the biosphere
- ☒ 5.1 Environment-dependent, molecular evolution in microorganisms
- ☐ 5.2 Co-evolution of microbial communities
- ☒ 5.3 Biochemical adaptation to extreme environments
- ☐ 6.1 Environmental changes and the cycling of elements by the biota, communities, and ecosystems
- ☒ 6.2 Adaptation and evolution of life beyond Earth
- ☐ 7.1 Biosignatures to be sought in Solar System materials
- ☐ 7.2 Biosignatures to be sought in nearby planetary systems
- ☐ This activity does not fit one of the above categories

Project Summary (NEW!)

A workshop "Cyanobacteria in the Lunar Environment", which was held on January 28-30 2008, brought together microbiologists, planetary scientists and experts in flight experiments and hardware to assess the value and feasibility of studying cyanobacteria in space environments.

Project Progress (Accomplishments)

Cyanobacteria are of great interest as model microorganisms to space programs because of their antiquity on earth, metabolic diversity, resilience to adverse conditions, ability to efficiently produce oxygen and hydrogen, and the existence of advanced capabilities for their genetic manipulation. Furthermore, cyanobacteria have considerable potential value for *in-situ* resource utilization (ISRU) and life support technologies. The workshop was aimed at generating a well-informed, systematic research program to address survival, acclimation, adaptation and utilization of cyanobacteria in space environments. Such a program has been developed within the context of current or near–future, experimental and exploration capabilities using ground, satellite and lunar platforms.

The workshop consisted of three types of activities. It started with longer, overview lectures aimed at familiarizing the interdisciplinary audience with the current state of knowledge in broad areas of interest, such as conditions on the Moon, biology of cyanobacteria and previous studies of microorganisms in space. These were followed by a series of shorter, more focused talks. The workshop closed with sessions in breakout groups aimed at identifying main scientific and technological issues that need to be addressed, and developing future R&D programs.

The participants were enthusiastic about the program of establishing cyanobacteria on the Moon. Since it would be the first demonstration that terrestrial life can exist in space beyond its planet of origin it would have great scientific and intellectual value. It was, however, recognized that the program would face considerable challenges, especially in dealing with radiation and negligible levels of nutrients. This would, in turn, require a comprehensive ground- and flight-based research. The participants were less optimistic about the chances of using cyanobacteria for ISRU, especially in short terms. In contrast, it was recommended that microorganisms could be effectively used in mid- and long-term technologies for life support systems.

Interdisciplinarity (NEW!)

The workshop was highly interdisciplinary in terms of both the profile of participants and the thematic range of talks. At the end of the workshop, three interdisciplinary groups prepared separate plans for research and development programs aimed at establishing microorganisms in a lunar environment.

Flight Mission Involvement

Identify how this project is involved with (or relates to) any NASA or international space or airborne mission(s).

none

Field Expeditions

Provide information about field work for this project. Use one table per expedition.

none

Cross Team Collaborations

Identify collaborative research with members of other NAI Teams during this reporting period. Include such details as the specific Teams, individuals involved, and the outcome of the collaborations.

The workshop was organized as a collaborative effort between members of the Ames and SETI teams. Participants included members of other NAI teams.

Images

If you are adding images, please list them in the table below (and attach separately). Please make it clear in your summary where the image should be inserted by placing the image designator (e.g. Figure 1, Figure 2, etc.) on a separate line/paragraph.

Image Number	Filename	Caption
Figure 1	cyanobacteria.tif	Cyanobacteria exhibit remarkable diversity in metabolism and phenotype
Figure 2	radiation_damage.tif	Radiation might the most damaging effect in space. However, terrestrial organisms developed a number of strategies to deal with this effect.
Figure 3	ISRU.tif	Cyanobactria can be potentially used for extraction of oxygen from lunar regolith in combined physiochemical and biological technologies. Here. Cyanobacteria split water into oxygen and hydrogen. Hydrogen is subsequently recycled into the physicochemical component that converts oxygen from regolith to water.
Figure 4		
Figure 5		
Figure 6		
Figure 7		
Figure 8		
Figure 9		
Figure 10		

Keywords

Please provide keywords to describe this project.

Space biology

Lunar science

Cyanobacteria

Microorganisms in space

Radiation effects on microorganisms

In situ resource utlization

Life support systems

Metabolic engineering